Despite growing interest, basic information on methods and models for mathematically analyzing algorithms has rarely been directly accessible to practitioners, researchers, or students. An Introduction to the Analysis of Algorithms, Second Edition, organizes and presents that knowledge, fully introducing primary techniques and results in the field. Robert Sedgewick and the late Philippe Flajolet have drawn from both classical mathematics and computer science, integrating discrete mathematics, elementary real analysis, combinatorics, algorithms, and data structures. They emphasize the mathematics needed to support scientific studies that can serve as the basis for predicting algorithm performance and for comparing different algorithms on the basis of performance. Techniques covered in the first half of the book include recurrences, generating functions, asymptotics, and analytic combinatorics. Structures studied in the second half of the book include permutations, trees, strings, tries, and mappings. Numerous examples are included throughout to illustrate applications to the analysis of algorithms that are playing a critical role in the evolution of our modern computational infrastructure.

Improvements and additions in this new edition include:

- Upgraded figures and code
- An all-new chapter introducing analytic combinatorics
- Simplified derivations via analytic combinatorics throughout

The book's thorough, self-contained coverage will help readers appreciate the field's challenges, prepare them for advanced results—covered in their monograph Analytic Combinatorics and in Donald Knuth's Art of Computer Programming books—and provide the background they need to keep abreast of new research.

ROBERT SEDGEWICK is the William O. Baker Professor of Computer Science at Princeton University, where was founding chair of the computer science department and has been a member of the faculty since 1985. He is a Director of Adobe Systems and has served on the research staffs at Xerox PARC, IDA, and INRIA. He is the coauthor of the landmark introductory book, Algorithms, Fourth Edition. Professor Sedgewick earned his Ph.D from Stanford University under Donald E. Knuth.

The late PHILIPPE FLAJOLET was a Senior Research Director at INRIA, Rocquencourt, where he created and led the ALGO research group. He is celebrated for having opened new lines of research in the analysis of algorithms; having systematized and developed powerful new methods in the field of analytic combinatorics; having solved numerous difficult, open problems; and having lectured on the analysis of algorithms all over the world. Dr. Flajolet was a member of the French Academy of Sciences.
COS 126 course objectives

Goal 1. Read, write, and reason about computer programs.
Goal 2. Apply concepts to science, engineering, and beyond.
Goal 3. Understand key ideas underlying computation and computer systems.

<table>
<thead>
<tr>
<th>topic</th>
<th>examples</th>
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</thead>
<tbody>
<tr>
<td>elements of programming</td>
<td>variables, loops, conditionals, arrays, I/O</td>
</tr>
<tr>
<td>functions</td>
<td>user-defined functions, modularity, recursion</td>
</tr>
<tr>
<td>object-oriented programming</td>
<td>user-defined data types, encapsulation, immutability</td>
</tr>
<tr>
<td>algorithms</td>
<td>sorting, binary search, stacks, queues, BSTs</td>
</tr>
<tr>
<td>theory of computing</td>
<td>universality, computability, intractability</td>
</tr>
<tr>
<td>design of computers</td>
<td>machine language, boolean logic, circuits</td>
</tr>
</tbody>
</table>
COS 126, Fall 2022

- digital revolution
- course mechanics
- course resources

https://introcs.cs.princeton.edu
The digital revolution

**Key idea.** “Everything” can be encoded as a sequence of **bits** (0s and 1s).

- Numbers and text.
- Pictures, songs, and movies.
- Your DNA.
- 3D objects.
- Computer programs.
- ...
The digital revolution

**Key idea.** “Everything” can be encoded as a sequence of **bits** (0s and 1s).

**Innovation 1.** You can **program computers** to process bits.

**Innovation 2.** Devices can use the **Internet** to send and receive bits.

> “Computers are incredibly fast, accurate, and stupid; humans are incredibly slow, inaccurate, and brilliant; together they are powerful beyond imagination.”

— *often misattributed to Albert Einstein*
Computers are transforming society

From the way we work ...

- Google
- Microsoft
- Apple
- hp
- SAP
- PeopleSoft
- Office
- Adobe
- MATLAB
- IBM
- Sun
- Oracle
- LinkedIn
Computers are transforming society

... to the way we live.
Computers are transforming society

From the “new” economy ...
Computers are transforming society

... to the way we do science and engineering.

- ocean modeling
- diffusion MRI of brain
- food web in Serengeti
- nuclear physics
- colliding galaxies
- an aerosol droplet containing coronavirus
- airflow over landing gear
The digital revolution has only just begun

In 2020. 50 billion+ smart connected devices, all developed to collect, analyze, and share data.
The digital revolution has only just begun

Welcome aboard. You’re already a consumer. Now, become a creator!

[ computer science education—a rare nonpartisan issue! ]
Use your new superpower ethically!

The Poison on Facebook and Twitter Is Still Spreading

Social platforms have a responsibility to address misinformation as a systemic problem, instead of reacting to cases as they arise.

Oct. 10, 2018

The New York Times

OPINION

Hospital Algorithms Are Biased Against Black Patients, New Research Shows

A University of Southern California study provides still more evidence that the company’s ad targeting illegally discriminates.

RESEARCH SAYS FACEBOOK’S AD ALGORITHM PERPETUATES GENDER BIAS

A study found that Facebook’s ad targeting illegally discriminates.

April 23, 2021, 5:30 a.m.

BROOKINGS

Twitter algorithm prefers slimmer, younger, light-skinned faces

Twitter’s algorithm is biased towards people with lighter skin tones.

10 hours ago

TECHTANK

For some employment algorithms, disability discrimination by default

Alex Engler · Thursday, October 31, 2019

An Algorithm That Grants Freedom, or Takes It Away

Across the United States and Europe, software is making probation decisions and predicting whether teens will commit crime. Opponents want more human oversight.

GETTY IMAGES
COS 126, FALL 2022

› digital revolution
› course mechanics
› course resources

https://introcs.cs.princeton.edu
Live lectures

20th century lecture
“Flipped lecture” format

Lecture videos (required). Watch studio-produced videos before precept.

Precepts

Active learning. Discussion, problem solving, pair programming, ...

- 50-minute precepts.
- 80-minute precepts.
- Makeup precept TTh 7:30–8:20pm (Zoom).
- Raspberry Pi precept (P15).

At the end of this precept, you should be able to:

1. Write code to print a message to a terminal (Activity 1: HelloWorld.java).
2. Write code to access command-line arguments (Activity 2: NameAge.java).
3. Write code to parse the numeric value from a String (Activity 3: NextYear.java).

This precept is based on:

1. Video lecture: Introduction to Java
2. Reading: 1.1

Note: Compiling/executing Java:

- You can use IntelliJ (if you already successfully installed it), or
- you can use Ed Lessons to compile/execute code.

If interested, see Alan Kaplan after class.
Class meetings

**Purpose.** Assignment overviews, debugging tutorial, exams, exam prep, ...

**Participation.** You are encouraged and expected to participate.
- Use iClicker to answer multiple-choice questions.
- Raise your hand and ask a question.
- Ask a question (anonymously) in Ed Discussion.

---

Kevin Wayne

-course staff will monitor forum
(may answer in forum or share with class)

https://edstem.org/us/courses/23780
iClicker (required). Mobile/web app is free for Princeton students.

Which iClicker device are you using?

A. iOS  
B. Android  
C. Web
Grading  A+

**Programming assignments (40%).** Assigned weekly. ← we drop your lowest score automatically

**Final project (10%).** Open-ended programming project.

**Exams (45%).**
- Two written exams (15% each).
- Two programming exams (7.5% each).

**Participation (5%).** Attend and participate in precepts.

**Course grades.** Uncurved.

<table>
<thead>
<tr>
<th>grade</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>93.0</td>
</tr>
<tr>
<td>A−</td>
<td>90.0</td>
</tr>
<tr>
<td>B+</td>
<td>87.0</td>
</tr>
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<td></td>
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</tbody>
</table>
Programming assignments

are an essential part of the experience in learning CS.

Desiderata.

- Illustrate a programming or CS concept.
- Highlight the role of computation in an important application.
- You solve the problem from scratch, on your own computer!
Programming assignments are an essential part of the experience in learning CS.

Desiderata.

- Illustrate a programming or CS concept.
- Highlight the role of computation in an important application.
- You solve the problem from scratch, on your own computer!
Submitting assignments

When?  Due Sundays at 11:59pm ET.

Preliminary feedback?  Click “Check Submitted Files” button.
Resubmit or unsubmit?  Yes.
All done?  Submit acknowledgments.txt file.

Submitting late?  10% penalty per (partial) day.

but we won’t start grading until after deadline

we waive first 4 late days automatically (after that, only with recommendation of DoS)
Final programming project💡

**Goal.** Design a substantive Java program on a topic you (and a partner) choose.

- Data analysis and visualization.
- Games and puzzles.
- Art and music.
- ...

we’ll provide guidance (including requirements and rubrics)
Programming exams

Goal. Write a short program (with the aid of a computer).

Problem. Develop a Java program that can draw one of several game boards, shown here:
Goal. Demonstrate your understanding of programming and non-programming concepts.

- Matching.
- Short answer.
- Fill-in-the-blank.
- Multiple choice.
- ...

2. Java basics. (8 points)

Suppose that the variables \(a\), \(b\), \(c\) are of type \(\text{int}\).

(a) Complete the following code fragment so that, after the last statement, the variable \(\text{max}\) contains the largest of the three values.

In each blank, write one of \(a\), \(b\), \(c\), or \(\text{max}\). You may use each variable name once, more than once, or not at all.

\[
\begin{align*}
\text{int max } &= \ a; \\
\text{if ( } &> \ \_\_\_\_ \text{ ) } &\_\_\_\_ \ &= \ \_\_\_\_; \\
\text{if ( } &> \ \_\_\_\_ \text{ ) } &\_\_\_\_ \ &= \ \_\_\_\_;
\end{align*}
\]
Covid-19 policies 🦠

**Face coverings.** Abide by university rules.

**This course.** Face coverings optional.

**Test positive?** Please stay in dorm; email Kobi Kaplan and cc your DoS.
Collaboration policies

Executive summary.

- *Do* discuss concepts with others.
- *Do* partner with a classmate (when permitted).
- *Do* acknowledge any collaboration with others.
- *Do not* copy code from others.

![Share your ideas!](image1)

![Not your code!](image2)
Have you met the person sitting next to you?

A. Yes.

B. No.
Icebreaker

Activity. Meet a classmate (that you don’t already know!) and discuss the following:

- What you hope to get out of COS 126.
- What you’re most excited about academically.
- What you’re passionate about non-academically.
- Then, keep chatting!
COS 126, Fall 2022

- digital revolution
- course mechanics
- course resources

https://introcs.cs.princeton.edu
Resources (web)

Course website.

- Syllabus and course policies.
- Lecture videos and slides.
- Precept lessons.
- Programming assignments.

Booksite.

- Download code from book.
- Brief summary of content.
- For use while online.

https://www.princeton.edu/~cos126

https://introcs.cs.princeton.edu
Resources (people)

**Ed Discussion forum.**
- Quick questions.
- Mark post private only when necessary.
- Please use Ed, not email.

**Office hours.**  protip: attend
- Longer discussions.
- See web for schedule.

**Intro COS Lab.**  opens Friday (tomorrow)
- Staffed by undergraduates.
- For help with debugging.
- See web for schedule.

https://www.princeton.edu/~cos126
https://edstem.org/us/courses/23780
https://introlab.cs.princeton.edu

Pulkit Singh '20
Resources (programming environment)

Recommended IDE. Custom Intellij 2022.2 environment.

- Embedded Bash terminal.
- Autoformat, autoimport, autocomplete, ....
- Continuous code inspection; integrated Checkstyle and SpotBugs.
- ...

uprade to our Fall 2022 version (see lab TAs for troubleshooting)
## Resources (ed tech)

<table>
<thead>
<tr>
<th>Platform</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ed</td>
<td><em>discussion forum, precept lessons</em></td>
</tr>
<tr>
<td>IntelliJ</td>
<td>Java IDE</td>
</tr>
<tr>
<td>TigerFile</td>
<td>assignment submissions</td>
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<tr>
<td>codePost</td>
<td>assignment feedback</td>
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<tr>
<td>Gradescope</td>
<td>exam feedback</td>
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<td>Canvas</td>
<td>check grades</td>
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<tr>
<td>iClicker</td>
<td>in-class polls</td>
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<tr>
<td>Zoom</td>
<td>hopefully, not needed!</td>
</tr>
</tbody>
</table>

*also use for communication with course staff*
If I don’t understand a TigerFile test my code is failing, what should I do?

A. Attend office hours.
B. Get help from a lab TA.
C. Post a question on Ed Discussion.
D. Email my preceptor.
E. Drop the course.
If I don’t understand a key programming concept, what should I do?

A. Attend office hours.
B. Get help from a lab TA.
C. Post a question on Ed Discussion.
D. Email my preceptor.
E. Copy a classmate’s solution.
A typical week (but not this one!)

<table>
<thead>
<tr>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
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<tr>
<td><strong>Video</strong></td>
<td><strong>Precept</strong></td>
<td><strong>Video</strong></td>
<td><strong>Precept</strong></td>
<td><strong>Class Meeting</strong></td>
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</table>

- **content based on week's material**
- **introduce new material**
- **support lecture videos**
- **assignment overview; exams**
Q&A

raise your hand and ask

ask on Ed (use ♥️ to upvote)